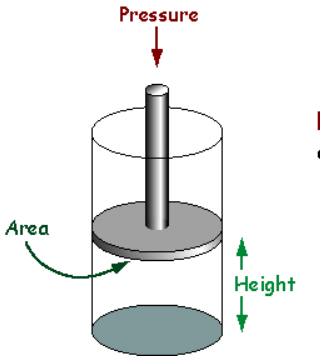
P-9.6 Apply fluid formulas to solve problems involving work and power.

Revised Taxonomy Level 3.2 C_A Apply procedural knowledge

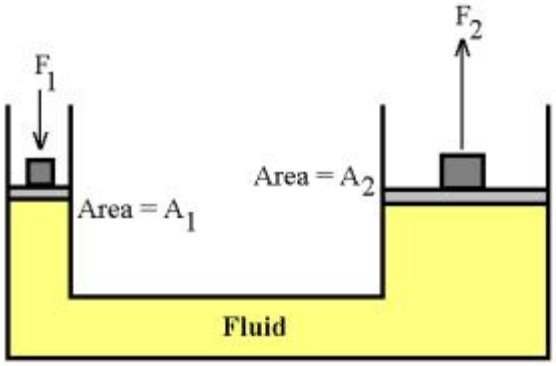
Students did not address power in physical science
It is essential for students to

- Understand that power is the rate of work so $P = p \times \Delta V/t$
- Understand that a common type of work is the work done by a gas through expansion or the work done to a gas through compression.



  - Pressure is the force applied per unit area, $P = F/A$
  - Pressure is measured in units of Pascals in the metric system (N/m^2)
  - Work is defined as Force applied over a distance so the work done by the fluid on the piston or the work done by the piston on the fluid is the force applied over the change in height of the gas chamber
    $W = F \times \Delta h$ where $\Delta h = h_f - h_i$
  - Therefore for a piston the work associated with moving a distance Δh can be found with the equation $W = p \times A \times \Delta h$
  - $A \times \Delta h$ is equal to the change in volume of the cylinder so $W = p \times \Delta V$
  - If ΔV is positive then the gas is expanding and doing work on the surroundings. So work should be negative $W = -p \times \Delta V$
- Understand and apply Pascal's Principle to hydraulic systems
  - "When there is an increase in pressure at any point in a confined fluid, there is an equal increase at every other point in the container."
  - Because the pressure throughout the fluid is equal to force x area

- In the diagram below, $F_1 \times A_1 = F_2 \times A_2$



- Pascal's law allows forces to be multiplied. The cylinder on the left shows a small cross-section area of 1 square meter, while the cylinder on the right shows a large cross-section area of 10 square meters. The cylinder on the left has a weight of one Newton acting downward on the piston, which lowers the fluid 10 meters. As a result of this force, the piston on the right lifts a 10 Newton weight a distance of 1 meter
- The 1 Newton load on the 1 square meter area causes an increase in pressure on the fluid in the system.
- This pressure is distributed equally throughout and acts on every square meter of the 10 square meter area of the large piston. $1N/m^2 \times 10m^2$ gives a force of 10 N on the right
- As a result, the larger piston lifts up a 10 Newton weight. The larger the cross-section area of the second piston, the larger the mechanical advantage, and the more weight it lifts.
- The following formulas are related to a hydraulic lift
  - $P_1 = P_2$ (since the pressures are equal throughout)
  - $F_1/A_1 = F_2/A_2$ (Since pressure equals force per unit area)
  - $V_1 = V_2$ (Because the volume of fluid pushed down on the left side equals the volume of fluid that is lifted up on the right side)
  - $A_1D_1 = A_2D_2$ where
    - A = cross sectional area
    - D = the distance moved

Assessment

The revised taxonomy verb for this indicator is implement (apply), the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving problems relating to power and work in fluid systems. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of fluid mechanics.